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ABSTRACT

This overview of the use of computers in education begins by tracing the history of the development of computer programs for instruction in three developed countries, the United States, the United Kingdom, and France. Significant research and programs, general trends, the current situation, plans, and problems in each of the countries are discussed, including statistics on the number of schools with computers, student usage, and the costs of programs. Ways in which computers have been introduced in schools in these countries are compared and differences in the strategies used are discussed. A more general discussion of the situation in other developed countries covers problems with hardware, software, teacher training, and evaluation of the effectiveness of computers for improving the educational process. A discussion of the use of computers in developing countries addresses similar problems in different cultural environments and educational systems. Policies and strategies for introducing computers in education at any level are also discussed, including policies for professional training, use of computers in schools, hardware, software, teacher training, and research. It is concluded that, although there is a definite danger of increasing the gap in level and quality of education between those countries that make massive use of computers in education and those that do not, the appropriate use of computers in developing countries can be a way of decreasing the gap. Of the seven sources listed in the bibliography, one is in English, one in Spanish, and five are in French. (MES)

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# PRESENT SITUATION, TRENDS AND PERSPECTIVES

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The use of informatics in education
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Introduction

The use of computers in education has started as a research activity on a very limited scale in the early sixties.

At that time computers were big and very expensive machines. Moreover, interactivity (in the modern sense) did not exist as the only way to communicate with a computer was to prepare a set of punched-cards to be sent to the computing center which returned a listing after a day or two.

The price of the equipment and the procedures to be used to get an answer made the use of computers in the classroom sound completely unrealistic.

In the late sixties however the situation improved through the advent of the minicomputer and the time-sharing mode whereby many users, each with his own terminal, could use the same computer at the same time.

In the early seventies, the decreasing price of equipment and the increasing availability of time-sharing systems led to small-scale experiments in schools in France, in the United Kingdom and in the USA which were funded by the

government or governmental agencies.

Because these countries started quite early and were therefore able to accumulate experiences over the last fifteen years we shall in this report call these countries the "Advanced Countries".

The advent of the microcomputer in the late seventies, its low price and its rapidly increasing use in industry, commerce and administration in developed countries has led an increasing number of these countries to plan the introduction of computers in schools.

These countries will, in this report, be called "Developed Countries", keeping in mind that there is no strong distinction between "Advanced" and "Developed Countries" the difference being introduced merely for the sake of simplicity as these two groups of countries do not face exactly the same problems.

All other countries will come under the name of "Developing Countries" keeping in mind that this group is not homogenous either as there are great differences between countries in this group.

1.- <u>The "Advanced Countries" - Present situation</u>

France, the United Kingdom and the USA share a number of caracteristics with other developed countries.

They have a computer industry since the early fifties, they have a great number of computers installed in industry, commerce and administration, a great number of professionals in computer science at all levels and well established curricula in computer science at universities, schools of engineering, polytechnics, etc.

The present situation regarding the use of informatics in education in these countries is however different from other developed countries for the following reasons :

- research in the use of computers in education has started before 1970,
- experiments in schools have started as early as the late sixties or the early seventies,
- the present ratio of number of computers to the total school population is better than one to hundred.

1.1.- History and state of the art in the USA

Between 1966 and 1971, over 150 million dollars have been spent by the National Science Foundation and the Office of Education only, not including many more millions spent at the state and local level for funding research projects on the use of computers in education.

The USA system of education being very decentralized, the federal government has little influence on it, the main responsability being with the governments of the different states of the union and with the local authorities.

It is therefore difficult to give a precise account of what happened in the schools all over the country as there are great contrasts between different states.

Generally speaking, the introduction of computers in schools has been the result of local or regional efforts and we shall therefore limit this report to the description of some well-known large scale projects and to statistical results when it comes to the

whole country.

The Plato project

This project was started at University of Illinois at Urbana in the early 60's on the Illiac I computer with a single terminal to investigate :

- the possible roles of the computer in the pedagogical process;

- the possibility to build a computer system with a powerful processing unit and a great number of terminals to compete, in terms of cost per hour and per user, with the traditional educational system.

Through successive extensions, the PLATO system, which is commercialized for many years by Control Data Corporation, uses a very powerful central processing unit with hundreds of terminals spread all over the country and linked to the central site through telephone lines. It is also available in other countries as the United Kingdom, Belgium, France, etc.

A recent version known as Micro-PLATO tries to overcome the cost of the use of telephone lines; instead of renting a simple terminal which has to be connected to the central site during a whole lesson, CDC is renting a PLATO microcomputer in which the software for any lesson requested by the user, can be down-loaded at high speed and in a short time through a telephone line from the central processing unit to the memory of the local microcomputer, the processing for the whole lesson being thereafter done locally without any further use of the telephone line.

One of the characteristics of PLATO is the use of a single programming language also known as an "author language" for writing all the courseware packages.

This language (TUTOR) was supposed to simplify the task of writing courseware packages by avoiding the necessity to learn a standard programming language like BASIC, FORTRAN or PASCAL. In fact, through successive extensions TUTOR has become at least as difficult to master as any other programming language.

The amount of available software packages is impressive as there are over 4 000 lessons available in over seventy different subjects.

It has had some reasonable commercial success in the USA as well as in other countries. For instance the University of Delaware has adopted PLATO in 1975 and during the academic year 1982-1983, about 29 000 students have used the system with a mean use of three hours per student. The University has about twenty terminals on campus and about ninety terminals out of campus.

From an economic point of view, PLATO has not been a success. Since the beginning, CDC has invested a total of about 1 000 million US dollars in PLATO with very little if any return up to now despite the hope expressed in 1975 by R. Norris, CDC vice-president in charge of Computer Based Education products and services : " By 1985, PLATO-related revenue could account for 50% of CDC's business".

The TICCIT Project

This project, funded by the National Science Foundation has been started in the early seventies by the MITRE Corporation and the Institute for Computer Uses in Education at Brigham Young University at Provo (Utah).

The TICCIT (Time Shared Interactive Computer Controlled Information Television) project did not succeed and has been abandoned after a few years of research

before it was really finished.

It is however interesting because its aims and scope were completely different from the PLATO project and, in many ways, complementary.

The hardware consisted of two NOVA 800 minicomputers, disk-drives, 128 terminals which were high resolution color-television receivers with added graphic possibilities and a keyboard incorporating a set of "learner control" keys as well as a standard typewriter keyboard. These terminals had to be on-site which means within 300 meters from the CPU.

PLATO and TICCIT are not only opposites in their scales (minis versus maxi, on-site versus remote access) they are also opposites in the sense that TICCIT is an integrated project in which the courseware is supposed to come as a standard part of the system.

Specific to TICCIT is the complete separation between course content and computer programming. More than that, course content and teaching strategy are also separated. This allows the strategy to be incorporated into a computer program at the operating system level, written by programming experts. This has allowed the writing of an integrated system in which a team of specialists including Instructional Psychologists, Subject Matter Experts, Design Technicians, Packaging Specialists and Programmers all cooperated.

Because of the variety of system outputs and the small memory available on the computer, the task of the software group became much more complex than initially planned with the result that the completion of the system took two more years than expected.

TICCIT has been tested in the middle seventies' in a few places like the Phenix

Community College and the Northwestern Virginia Community College but the high cost of producing courseware in the TICCIT environment and various delays in the debugging of the system finally led to abandon the project.

The PCDP Project

The PCDP (Physics Computer Development Project) project was started at the Irvine Campus of the University of California at the time the campus was set up in 1965.

This project has been on-going since that time and is characterized by a very pragmatic approach at all levels : terminals, software, courseware and authoring system.

The privileged mode of use is through "dialogs" which in fact may include tutorial, drill, simulation, etc, depending on the subjects and the intended audience.

The terminals used are remnant cathode-ray-tubes with a keyboard and full graphic capabilities.

Regarding the philosophy of the project, it is best to quote the project recommendations :

"The key person in the preparation of a learning sequence is the competent teacher with experience and insight into the learning process. Hence the first problem in producing computer-based teaching materials is to identify and to involve such teachers".

"The teachers who have prepared our material have very different teaching philosophies; it is no secret that good teachers disagree highly about just how to

teach effectively. As a project, we favor no single teaching style or philosophy."

"We have a very satisfactory mechanism which obviates instructors from learning computer languages and becoming computer experts."

"This method allows teachers to do what they can do best, teaching. It precludes their spending weeks learning a programming language."

Despite its experimental aspects the PCDP project has been working for many years and is currently used by thousands of students each year on a free-service basis. It is worthwhile to note that the majority of students using the computer based physics teaching are those whose major is <u>not</u> physics.

1.1.1.- <u>The present situation</u>

Since the advent of the microcomputer in the late seventies the situation has changed as more and more microcomputers are coming into schools.

As already said there is no national plan and computers come into schools through decisions made at the regional (state) or local (county) level. Moreover the computer industry is helping either by high discount rates for schools or even by giving microcomputers to different schools.

The production of courseware is almost completely left to private companies and there is no general policy for teacher training.

Finally over the last five years the general trend was towards using computers to teach "computer literacy" which in most places included : computer structure, programming in BASIC or in LOGO, the impact of computers in commerce, industry and administration and on society at large with more or less emphasis on the

different subjects, depending on places.

Recently there has been a change in emphasis and there is now a trend towards "computer literacy in disciplines" with emphasis on : how to teach a discipline using a computer, how will the use of computers change the content of what is taught in a discipline, etc.

Primary education (six to eleven years old)

41% of all primary schools own at least one computer and out of these 7% own at least five microcomputers or more.

Because of the decentralization of the USA educational system, schools and local authorities can choose freely their equipment.

However some school districts have set up technical centers to help administrators and heads of schools in choosing the right equipment and selecting courseware.

For instance the state of Minnesota has created the Minnesota Educational Computing Consortium (MECC) which has recently become a private company which evaluates and distributes courseware packages as well as thousands of microcomputers for all levels of teaching.

The same kind of services is available in other places like the "Houston Independant School District", the "New York State Center for Learning Technologies", the "Educational Collaboration Center of Greater Boston", etc.

In primary education the general trend is to give access to the greatest possible number of children to the existing equipment which implies that each child has a rather short access time to the computer.

Statistically, in primary schools, a microcomputer is used about eleven hours a week (a little over two hours a day). In fact, the practical use varies widely from school to school.

One school out of seven says that the computer is used over five hours per day while 25% of the schools that they use the computer only during one hour per day.

In a typical primary school, 80% of the children have access to a computer during less than thirty minutes each week while one child out of fifty has more than one hour of access each week

Typically about 40% of the time the computers are in use is spent for exercises in mathematics, spelling and memorizing. Another third is spent by teachers for copying and evaluating courseware and the rest is used for pedagogical games.

Secondary education (twelve to eighteen years old)

Between 77% and 85% (depending on sources) of all secondary schools own at least one microcomputer. Out of these, 40% own at least five microcomputers or more.

Secondary schools have, for computer access, quite a different policy from primary schools. They choose to restrict the access to computers but to give to some of their pupils a longer access time.

Statistically, in secondary schools, microcomputers are used about thirteen hours a week. Here again the real use of computers varies widely from school to school. 20% of the schools say that they use each computer over five hours each day but 20% of the schools use each computer only one hour each day.

Typically, the majority of children in a secondary school have access to a computer for forty five minutes each week but two children out of five have more than one hour access per week.

About 70% of the computer time used by the children is for "computer literacy", 18% is for drill and practice and the rest for pedagogical games, text processing and lab work.

In many secondary schools informatics is taught as a subject during three hours each week for twenty weeks to children over fourteen years old (mainly programming) while the use of computers for teaching mathematics, sciences and foreign languages increases as the corresponding courseware packages increase in quality.

The courseware problem

Since the beginning, the states and the local school authorities have paid for most of the hardware but have not participated significantly to the funding for courseware development.

Some packages have been written by university professors with funds from the federal government but most of the existing courseware packages have been produced by private companies and the mean quality of these products is generally considered as rather bad.

This is probably due to the fact that the companies are small and cannot afford the right manpower to produce high quality products.

About 750 companies are producing software packages to be sold to schools and

many thousand packages are available mainly produced by book publishers like Addison Wesley, Giner and Co, Random House, Mac Graw Hill, Scott Foresman, etc. but show-business companies are also entering the market like Walt Disney and Children Television Network.

Several institutions have been created to try to help schools in their choice of hardware or software :

- the Minnesota Educational Computing Consortium already mentionned,

- the National Co-ordinating Center for Curriculum Development which is part of the State University New-York at Stony Brook,

- the Northwestern Regional Laboratory has set up an information center called "MICROSIFT" which role is to gather and evaluate available software packages to inform teachers in schools about the content and the value of the packages,

- the Conduit Consortium (Iowa) which has been formed by a group of about a dozen different universities for selling software packages at a low price (ten to fifty dollars) and which is a not-for-profit organization. The originality here is that Conduit does not produce courseware but has a number of experts for reviewing proposed packages and it sells only those which have been accepted by those experts.

The availability of courseware for the classroom is one of the main difficulties as most of the existing courseware, except those for the teaching of reading, does not generally fit existing curricula in schools.

Trends and perspectives

During the last few years the public opinion in the USA has been very favorable to the introduction of computers in schools and this is why the number of computers has steadily increased from 130.000 in 1982 to about 700.000 in 1985.

In January 1983 about 60% of all US schools owned at least one microcomputer with some differences between primary schools (40% owning at least one microcomputer) and secondary schools (80% owning at least one microcomputer). and for 1983/1984 the total expenses for equipment were about 200 million dollars with a price range from 1 000 to 2 000 dollars per computer.

This tendency towards the increase of the number of computers in schools is probably to go on for the next few years and some experts predict a ratio of one microcomputer for 20 children towards the end 1987.

Some experts do not even hesitate to say that computers in schools is the only possible asnwer to some of the difficulties of the US educational system as described in the report "A nation at risk"; the main argument being that a massive use of computers by children could help to overcome the insufficient level of training of teachers and at a lower cost than the one involved in retraining all US teachers.

However, quite recently, a number of articles have started appearing which question the role of computers in education as a universal panacea and insist on the fact that there is no use of putting computers in a school, even if they are given free, as long as the teachers do not know for what educational purpose they are going to use them.

Moreover some university professors warn that computers in education may well

follow the fad-and-reject cycle which has already been the case for previous technological tools as the film and television, a new technology being rejected and put aside as soon as the excessive predictions of improvement of education do not show up in practice.

Because of all these contradictions, the "National Institute of Education" has formed a "National Task Force on Educational Technology" to recommend a set of private and public strategies for the next few years. The report of the Task Force has not yet been published but it is already known that the report will recommend a multi-media approach to education where computers have a role to play but not an exclusive one.

1.2.- The UK experience

The UK school system

The UK school system can be divided in a system covering England, Wales and Northern Ireland and a system for Scotland. Both systems are very decentralized in the sense that there does exist a Department of Education and Science at the government level but the school system depends much more from Local Educational Authorities (LEA's) than from the central government.

There is however a strong link between the Department of Education and Science and the school system through the Schools Council (created in 1964) which is an independant body and funded equally by the department of Education and Science and the local education authorities.

The Schools Council develops the curricula, undertakes educational research, approves new A-level syllabuses (final examination of secondary education) and advises the Secretary of State on the examination system.

The NDPCAL Project (1973-1978)

Aims and scope

The National Development Programme in Computer Assisted Learning (NDPCAL) has been a remarkable innovation in the area of financing educational change.

The Department of Education and Science decided in 1973 to earmark two million pounds for testing and developing the use of the computer as an aid to teaching, to be distributed through an independant agency.

A small Directorate for NDPCAL was established by Richard Hooper in 1973; its number fluctated but never exceeded seven people including secretarial support.

The overall direction and control of policy remained with a Programme Committee of twenty-two members containing representatives of seven government departments and of bodies such as the Council for Educational Technology, Schools Council, University Grant Committee and Social Science Research Council and an important group of coopted advisers from academic, technical and industrial organizations.

The Programme Committee received proposals for projects after they had been developed jointly by the Directorate and the projects staff; and these had to be approved by the Programme Committee.

Right from the beginning it was decided to have two evaluation reports made by people outside of the project. One of the report had to be an educational evaluation and this was carried out by a team led by Barry Mc Donald of the Centre for Applied Research in Education at the University of East Anglia and the other report had to be a financial evaluation carried out by John Fielden and Philip

Pearson both members of a Management Consultant Office.

Moreover, the aim for NDPCAL beeing "to develop and secure the assimilation of computer assisted and computer managed learning on a regular institutional basis at reasonable cost" (Richard Hooper) all institutions which submitted a project were invited to fund their project with an amount equal to the amount given by NDPCAL. It was hoped that this policy would encourage the use of computers in education even after the end of the project.

Finally the NDPCAL had two objectives :

- Computer Aided Learning (CAL),;
- Computer Managed Instruction (CMI).

The CAL projects

Altogether there have been seventeen CAL projects funded by NDPCAL :

- nine in higher and further education,
- three in secondary schools,
- two in industrial training,
- three in military training (one Royal Navy, one Army, one Royal Air Force).

The nine projects in higher and further education (universities and polytechnics) are the most significant part of the achievement of NDPCAL as they are mostly inter-institutional. Towards the end of the NDPCAL project there were 29 participating institutions in the nine projects which are :

- Computer Based Learning Project,

- Engineering Science Project,

- Computational Physics Teaching Laboratory,

- Clinical Decision Making (Medicine),

- CALCHEM (Chemistry),

- MATHLAB (Mathematics),

- Computers in Undergraduate Science Curriculum,

- Basic Mathematics,

- CAL - a university service.

The programs written to implement the projects are in the form of packages (450 altogether) but the size of the packages are widely spread from 100 lines of code to over 10.000, the mean being around 700 lines of code per package.

The programming languages used were FORTRAN, BASIC and special "author-languages".

However one important remark is that the time devoted by academic staff in writing the packages was generally no more than 10 to 20% of the total time, the bulk of the job being done by programmers hired on NDPCAL funds. If this is added to the fact that it was estimated that no more than 20 to 30% of the staff funded by NDPCAL would be funded by the institutions after the end of NDPCAL then there is

a serious problem for institutionalization of CAL in the absence of outside funding unless CAL is ranked high in institutional priorities.

In agreement with findings in most places, the time needed to develop a one-hour interaction package has been found to be in the order of 100 to 300 hours.

Moreover it has been found that there was no real learning curve in package development which means that as programmers and academic staff gained experience of CAL there was no decrease in the time needed to develop new packages. The reason for it is that, as time goes on, packages become more and more complex and programmers as well as academic staff seek new challenges once they have mastered the easy work.

The average use per terminal in hours has been well under the level of the forecasts made at the beginning. Whereas a feasibility study made by the National Committee for Educational Technology predicted in 1969 an average use of 2 000 terminal hours each year, experience has shown that the real use has been somewhere between 150 and 500 hours per year depending on the institutions.

The three projects of CAL in schools are not significant. Two are in history and one in geography and in all three cases computers were used through inquiries sent through the postal service to be processed in batch mode and then sent back to the schools. They are not significant also in terms of funding, the funding from NDPCAL being less than 6% of the total resources for CAL.

The two NDPCAL projects in the area of industrial training are both of little interest as they offer no base for generalization and used together no more than 6% of the total budget of NDPCAL for CAL.

One of the projects called "Management Decision Making" at the London Business

School did not follow the planned course of development and did not finally solve the complex educational issues involved.

The other was concerned with the training of technicians from the Post Office in the maintenance of customer's equipment but did not achieve up to what was expected.

Anyhow, despite the fact that it was believed towards the end of the NDPCAL project that CAL would probably not be used, statistically, more than 10% of the time of each student in 1976/1977 over 35.000 student-terminal-hours was recorded and a significant part of the projects started with the help of NDPCAL have continued in a number of institutions.

The CMI projects

Computer Managed Instruction (CMI) also called Computer Managed Learning (CML) deals with the use of computers as an aid to educational management where computers are used, at frequent intervals, for recording, marking, assessing, directing or recommending and reporting.

The computer plays the role of a tutor, delivering tests and, depending on the marking of the tests indicates a set of learning modules to be taken by the student.

A complete system of this kind is generally a large project taking a long time to implement and involving complex system software but partial systems implementing only a subset of all functions mentionned are also possible.

Moreover a CMI system can be either specialized or "content-specific" for one particular application or it can be "content-free" in the sense that it has no inbuilt course content or type of reporting but is easily adaptable to any particular need.

The most important CMI development within NDPCAL is a software package called "CAMOL" (Computer Management Of Learning) which is a large content-free system initially developed by the UK Company ICL.

Part of the system and most of the educational material for applications have been developed with NDPCAL funds.

There are two main applications :

- at the New University of Ulster (course on curriculum design and development partly based on material produced by the Open University and partly on locally prepared material) which concerns about 200 students each year and represent onethird of the students work load for one half of an academic year,

- at Brighton Polytechnic where CAMOL is mainly used for test-marking, question analysis and record keeping for about 600 students each year.

Dissemination

NDPCAL has funded two small organizations for exchanging and disseminating CAL products. They were intended to collect packages, test and eventually modify them and distribute them upon request to their members.

The Physical Sciences Programme (PSPE) disseminates small packages mainly in Physics and Chemistry to their members who are professionals able to modify or even translate the packages in another programming language. The membership is about 50 and the requests for programs are in the range of 30 a month. Given the small staff of PSPE the cost of a package is around 10 £.

The Geographical Association Package Exchange (GAPE) has a membership with no or little knowledge of computers. They have a small central staff for soliciting, testing and amending packages, the distribution being based on a number of regional centres based on colleges, polytechnics and universities and from them to local schools. At the end of the NDPCAL project they had already distributed 270 copies of packages to 70 schools, colleges, polytechnics and universities.

Costs

As already said the total cost of the NDPCAL project from 1973 to 1978 has been 2,5 million pounds under the following headings :

| | |
|---|---|
| Computers, terminals | 400,000 £ |
| Staff working on projects | 1 600,000 £ |
| Travels | 100,000 £ |
| Others | 400,000 £ |

The matched funding from the institutions amounts to a total of about 2 million pounds half of which has been spent on hardware so that the total cost of the project is in the range of about 4 million pounds.

Careful analysis by an evaluation group has led to the following conclusions :

- cost-benefit techniques are not relevant to CAL and CMI whose outcomes cannot generally be quantified,

- projects vary greatly in unit cost terms; some CAL applications cost less than 5 £ a student-hour and others over 20 £,

- CAL and CMI do not replace anything; they represent and add-on cost

The Micro-electronics Education Programme (MEP)

As early as 1979 the British Government announced at 12,5 million £ programme of support for micro-electronics education in schools. This programme did not start but in March 1980 the Department of Education and Science started the "Micro-electronics Education Programme" with a total funding of 9 million £ for four years.

About a year later Richard Fothergill, the director of MEP supported by a small team of seven people was operating from offices based in Newcastle upon Tyne.

The programme is responsible to the Departments of Education of England, Northern Ireland and Wales and it operates through contracts administered by the Council for Educational Technology. MEP is aimed at primary and secondary schools in England, Northern Ireland and Wales and there is a different programme for Scotland (Scottish Micro-electronics Programme).

Aims and objectives

MEP has two main objectives :

- to investigate the most appropriate way of using the computer as an aid to teaching and learning, as a guide to the individual child, as a learning aid for small groups of children or as a system which involves the whole class. Software can be developed for computer based learning across the curriculum but the Programme will give priority to applications in mathematics,

the sciences, craft/design technology, geography and courses related to business or clerical occupations,

- to introduce new topics in the curriculum, either as separate disciplines or as new elements of existing subjects. The new topics (at varying levels of specialization) include :

1. Micro-electronics in control technology,

2. electronics and its applications in particular systems,

3. computer studies,

4. computer-linked studies, including computer aided design, data-logging and data processing,

5. word processing and other electronic office techniques,

6. use of the computer as a means of information retrieval from data-bases.

In order to implement the Programme three main needs of teachers were identified which had to be met for a successful action :

a) inform teachers about activities and developments in the field,

b) train teachers in the methodology of using computers effectively in the classroom,

c) to develop materials to be used by the teachers and examine the whole issue of computers in the curriculum.

Despite the absence of microcomputers in schools it had been agreed that MEP resources would not be used for the purchase of large quantities of equipment.

In fact a special project "Micros in Schools" was started by the Department of Industry to help secondary schools buy computers. Through this project (for a total of one million £) secondary schools could buy one out of two British made micros at half price, the other half of the price being paid by the project.

About 5 000 secondary schools had bought a microcomputer under this scheme at the end of 1982.

Moreover in July 1982 a second project "Micros in Schools" was launched for the 27.000 primary schools at the same conditions.

One important feature of these schemes has been their insistence on having at least two teachers receive basic training on the equipment as a condition of purchase.

Management.

Because of the small amount of money available it was impossible to work directly with the 109 LEA's. Therefore all LEA's were grouped into fourteen regions and further on it was decided that two thirds of the funding would go to regional initiatives and one third only to national initiatives.

Each Regional Center has an "Information Centre" containing a software library and other relevant teaching material for use in the classroom including videotapes, slides, audiocassettes, books and electronic devices.

Many of these are produced by the Programme but commercially developed

materials are also available.

In each Region there are four training centers normally based in LEA's where courses are given on four main themes :

- technology domain including electronics, control technology and industrial applications,

- computer domain including computer studies and the computer as a device,

- computer based learning domain including the use of equipment as an aid to teaching across the whole curriculum,

- communication and information domain including business studies and the changing role of information.

In each region there is a regional coordinator in each domain and above these there is also a national coordinator in each domain.

A variety of courses are normally available :

- one to three days courses for beginners,

- one week courses for those having already taken the beginner's course,

- three months courses for those who want to specialize or to write courseware,

- teachers's teachers courses.

For each region there are 60.000 £ reserved each year for organizing courses and

as the daily cost is evaluated to about 25 £ a day this leads to about 2.400 teachers-days per year and per region.

Moreover courses at-a-distance are given by the Open University, the BBC and the National Extension College.

Courseware

Because of the delays and cost in producing courseware this is the least available resource.

Evaluations of the necessary resources made in Britain have lead to the following conclusions :

For having in each school one course/in a week using the computer there is a need of about 1 000 different packages; if the computer is to be used during one course every day than there should be about 5 000 packages available.

At the end of 1983 there were in Britain about 60 publishers selling courseware at prices between ten and thirty £ and at these prices most publishers are loosing money.

For children in the age range six-fourteen years old there are about 250 packages available commercially.

However MEP is encouraging the production of courseware packages by teachers and funding some projects from GAPE (already mentionned about NDPCAL) and from the "Computers in the Curriculum Project" based in Chelsea College.

MEP is asking groups of teachers to submit projects at the Regional level and will

fund some of these after pedagogical evaluation by the National School Council.

The dissemination of software packages is one of the roles of the already mentionned Regional Information Centres which are invited to work along the lines of two organizations set up during NDPCAL : Project CEDAR (Computers in Education As a Resource) at the Imperial College and the different SATROS (Science and Technology Regional Education) which are organizations for disseminating to all their members the packages written by some of the members.

There are other organizations which help to disseminate available packages like MUSE which publishes a journal called "Computers in School" and which centralizes and sells about fifty packages at prices between one £ and two £ (exceptionally ten £) and like MAPE (Micros and Primary Education) which publishes the journal "Micro-Scope".

Finally to encourage the use of computers in education for each microcomputer bought by a primary school, MEP gives free thirty packages.

Conclusion

After project NDPCAL from 1973 to 1978 where over 50% of the five million £ available was spent for staffing and which left over a number of on-going CAL activities after the end of the project, the MEP again has emphasized the importance of teacher training with a total amount of about nine million £ in four years and a very decentralized organization to bring the training as near as possible to the teachers. The buying of equipment was encouraged with the objective of one computer per school with a one million £ project for secondary schools and a nine million £ project for primary schools whereby the schools paid 50% of the price and the project the other half. Despite efforts made by NDPCAL and MEP courseware packages is still a scarce resource and will probably remain,

for some years, an obstacle to rapid spreading of the computers in schools.

1.3.- The French experience

Setting the scene

The way computers have been introduced in education in France is strongly related to the structure of the French system of education; therefore a few words of introduction are necessary for those readers not familiar with this system.

The entire French educational system is strongly centralized with a hierarchy ranging from the teacher up to the Minister. All teachers, from kindergarten up to University level are government employees, all curricula are completely defined down to the least detail by the Ministère de l'Education Nationale; they are compulsory for all schools and the curriculum for each school-year is the same in all schools all over France. Moreover, for teachers, the number of teaching hours per week are also determined by the Ministre. Finally all examinations are national which means, for instance, that for the "Baccalauréat" which is the examination all students take at the end of secondary school (18 years old), all students (about 200.000) all over France have to go, the same day and at the same hour to examination centers where they have to work on exactly the same subject.

The Ministère de l'Education Nationale with his 600.000 teachers and professors, with about 500.000 civil-servants working in offices and about 13.000.000 pupils and students has been called the biggest company in France with a budget of approximately 18% of the total budget of the country.

Since a few years a real effort has been made to deconcentrate and decentralize this enormous monolith. The country has been divided in twenty-seven academic regions (each region is called a "rectorat") under the authority of a "recteur"

nominated by the Ministre. Each region is, again, subdivided in smaller districts (100 alltogether) under the authority of an "inspecteur" who is, again, nominated by the Ministre.

Although it has some drawbacks, such a centralized educational system has advantages when it comes to decision-making and implementation of changes as shown during the introduction of computers within the French educational system.

The cold start (1970-1976)

In 1970 a Commission preparing the 6th Five Year Governmental Plan discussed the introduction of computers in education and the official Report of that Commission (La formation en informatique pendant le 6ème Plan - 1971) made a distinction between (a) training Computer Specialists, (b) introduction to Computer Science and (c) more general information to make Informatics familiar to a large number of students. For obvious reasons this last objective had to be achieved in secondary schools through general education.

In that same year, without waiting for the conclusions of the Commission, the Ministre de l'Education appointed W. Mercouroff as "Chargé de mission à l'Informatique" whose role was to implement the different conclusions of the Report of the Commission.

The pedagogical objectives of the first phase

When in 1969 Professor W. Mercouroff was nominated *chargé de mission à l'informatique* at the Ministry of Education for introducing Computer Science in secondary education, he agreed that Computer Science was definitely not a subject to be taught in general secondary education because computer structure and programming were technical skills and, therefore, not relevant to *general*

secondary education.

Moreover, he did not agree with the Skinnerian theory of learning which is too heavily based on behaviorism where the student is considered as a black box whose 'competence' is strictly evaluated in terms of input-output (i.e., correct or incorrect reaction to a given stimulus) without any reference to the mental processes going on in his brain.

Piaget's approach, which is the opposite of Skinner's approach, seemed much more realistic because it emphasizes the interior of the black box and *explains* the relationships between stimulus and reaction instead of simply observing them.

Therefore, programmed learning was discouraged and teachers were asked to develop courseware based on simulation and modelling in all disciplines.

Operation

Naturally, the different operations carried on overlapped, but they were launched successively.

*Teacher Training* 530 secondary school teachers of various disciplines were trained in universities, for a full academic year, on a volunteer basis, between 1970 and 1976. In addition, during the same period, more than 5 000 teachers took a correspondence course in computer science specially established and oriented toward applications in secondary education.

After the training, the teachers resumed their teaching duties in their schools. Each of them was asked to implement a pedagogical use of the computer in his discipline, and to experiment it with pupils. All these projects were coordinated by the *Institut National de la Recherche Pédagogique* (INRP), which is to say the

French national pedagogical institute.

*Choice of Programming Language* In order to disseminate the courseware written by teachers, and to avoid spending time and money in rewriting programs from one language to another, a specific programming language was created by the Computer Department at the *Ecole Supérieure d'Electricité.*

This is the *Langage Symbolique d'Enseignement* (LSE). It is a French speaking, highly interactive, ALGOL-like language, simple enough for beginners yet sufficiently sophisticated to be effective for experienced programmers.

*Computers Installed* A standard hardware configuration was defined and several minicomputers - the MITRA 15 from the *Compagnie Internationale pour l'Informatique* and the T 1600 from *La Télémécanique* - were ordered in 1972. In 1976, 58 such minicomputers were installed in secondary schools (and gave the name to the experiment). These computers were time-shared, and accomodated eight terminals and a printer; later, a floppy disk was added.

Results

The experiment of the 58 secondary schools was rather unique. Its development was stopped in 1976, but it lasted until 1980 with the same equipment. At the same time, a team from INRP started an evaluation of the experiment. The main results of this evaluation are :

. during the experiment, 45.000 students (one out of two) and more than 1.000 teachers (one out of six) used a computer each year in the equipped schools;

. the computers were used an average of 32 hours per week, 25 weeks per year (800 hours in a year);

. a set of more than 400 courses written by teachers was centralized, evaluated, documented and distributed by INRP;

. general information on informatics was effectively given; moreover, some volunteer students received an initiation into computer science;

. lastly, the introduction of informatics has been achieved through all disciplines, not only in mathematics and science.

There are however additional remarks :

. despite official instructions there is an important number of packages using programmed learning (mainly in French grammar or foreign languages).

. the majority of courseware packages in experimental sciences are using simulation and modelling.

. during the one-year full-time training, too much emphasis has been put on computer structure and programming *per se*, and not enough on the pedagogical use of computers; this has produced some harmful results; for instance a nonnegligible number of teachers have been fascinated by the machine and have become unconditional computerniks supporting the idea that it is important to teach computer science as a separate discipline (the probable reason behind this attitude is that it is more fun to play around with computers than to teach algebra or history); another harmful result comes from the fact that many teachers had great difficulties in mastering the use of a programming language and had, therefore, a tendency to consider that the challenging part in a courseware package was the writing of the program and not the definition of the pedagogical objectives. The net results are some packages of little real value because their objectives are trivial or could be

achieved with pencil and paper or in book form.

. despite the fact that almost all teachers realized that producing a package was a difficult and time-consuming activity, many of them had a very critical attitude towards pakages written by others (the not-made here syndrom).

Since few similar projects have existed on the same scale, it is difficult to compare France's experimental use of computers in education with experiences elsewhere. Perhaps the only comparable experience is the NDPCAL Project in the U.K., which lasted from 1973 to 1979, and had a budget of the same order of magnitude - about five million dollars. NDPCAL, however, was mainly aimed at the university level. Out of seventeen projects, only three were in secondary education, and all three were in history and geography.

Even so, similar remarks can be made regarding both projects :

(1) about 60 percent of NDPCAL's budget was spent for staffing, whereas in France about 70 percent of the budget was spent for the same purpose - teacher training and package-writing.

(2) the evaluation of terminal use during NDPCAL showed a mean use of 500 hours/year; during France's experiment, the terminals were used about 800 hours/year.

(3) during both projects, the amount of time needed to write a one-hour interactive program was somewhere between 100 and 300 hours.

(4) in both cases, the best packages generally were produced by teachers working in teams.

(5) for both projects, the emphasis in teaching mode was on modeling and simulation, and the attitudes of students were very positive - in these modes, the student has the initiative in dialogue.

(6) from both projects, experts concluded that CAI will not replace anything but will add on to what already exists.

The 10.000 microcomputers plan

By 1979, the first generation of microcomputers had arrived, mainly based on 8-bit microprocessors using floppy disks as auxiliary memories. They were far from professional standards in terms of versatility, reliability, and sophistication of operating system. Nevertheless, it was evident that second-generation microcomputers - including all necessary features - were close at hand.

For this reason, the French ministries of Education and Industry jointly launched a five-year plan in 1979 to install 10.000 microcomputers within secondary schools for use with students between the ages of eleven and eighteen.

The decision to implement that plan had to take into consideration the situation as it stood at the beginning of 1979. At that time, experience was accumulating in the instructional use of time-shared systems; however, no experience existed in such use of personal computers. Under the earlier project, 600 teachers had been fully trained to the level of being able to write courseware packages, and about 5.000 teachers had completed a correspondence course on the basics of computer science and the use of computers in education. Furthermore, a bank of more than 500 fully portable courseware packages already existed. It was also obvious that first-generation micro- computers were not the best choice for use in education. Finally, a national data transmission net - including home terminals - was under way.

These considerations led to four major decisions. The first was to install 1.200 microcomputers during the coming two years - 400 in 1980, and 800 during 1981 - each time choosing the best machines available. It was also decided that after two years of experience with personal computers, it would be possible to make a thorough comparison of personal computers and local time-shared systems from a pedagogical point of view and, as a result, define the best kind of equipment to use

The third decision was to make LSE a standard language. To this end, a request for a standard was introduced before the French National Bureau of Standards, AFNOR. Apart from avoiding the obvious problem and expense of translating programs from one language into another, there are two other reasons supporting this decision. The first is to make maximum use of the existing bank of about 500 programs which are already fully documented and tested, 70 percent of which have been ranked by users as being "fairly good" to "excellent". The second reason is pragmatic - it is easier to convince a teacher of the value of using a computer in the teaching/learning process by providing him with an easy-to-use courseware package designed for his discipline than it is by requiring a lengthy and complex process of education in the basics of computer science and the subtleties of programming. Moreover, it is fairly evident that in the future the majority of teachers will be users of packages and only a minority will be involved in the design and writing of packages.

Finally, for the academic year 1979-1980, forty teachers - selected from those who earlier received a year of training - were given a year of release time at regular salary, during which they will visit and direct short seminars with other teachers at those schools which will receive the microcomputers (eight per school) mentioned earlier. A three-week seminar, held in October 1979 for these forty teachers, provided them with the necessary training for directing these seminars.

The 100 000 microcomputer plan

In 1981 after the election of President Mitterand the 10.000 microcomputer project was frozen for a few months and Professors C. Pair and Y. Le Corre were commissionned to write a new report. This report concluded to proceed with the project with the same aims and objectives as previously and recommended also to set up a small experiment (twelve secondary schools) to evaluate the teaching of informatics as an optionnal subject in the range sixteen-eighteen years old.

Simultaneously, the report recommended that the short seminars to be given in the schools receiving the equipment should not be less than 100 hours spread over two weeks and defined the content of a full-time course (thirty weeks) for teacher's teachers training which started in October 1981.

This same year were created eleven "Centres de Formation à l'Informatique et à ses Applications Pédagogiques" (Centers for education in informatics and its pedagogical applications) mainly in Universities for teacher's teachers training with a curriculum of 750 hours (300 hours for general informatics, programming methods, etc, 300 hours for CAI and 150 hours for planning future activities in teacher training).

In 1982, about 230 teachers were trained in the eleven Centers. In 1983 the number of Centers went up to fifteen with 300 teachers trained for thirty weeks whereas the 230 teachers of 1982 were used full-time for teacher training in the schools receiving their equipment.

In 1984, there were twenty Centers and about 500 teachers altogether had been trained during a full academic year.

The objective is to have one Center in each "Academie" (twenty-seven altogether

within the next few years.

During that same time, the number of teachers trained in short seminars (100 hours) has increased. From 1981 to 1983, about 20.000 teachers were trained whereas another 20.000 teachers will be trained during the academic year 1983-1984.

While the rythm of teachers training increased since 1981 so did the amount of hardware put in schools. While at the end of 1981 there were alltogether about 1.200 computers installed (eight microcomputers in the range 2500 $ US per computer + a line printer in each school), this number went up to 6.000 at the end of 1983.

In that same year 1983, the "Ministre de l'Education Nationale" announced that the 10.000 microcomputers project was cancelled and replaced by a new and more ambitious "100.000 microcomputers project including the training of 100.000 teachers" to be achieved in 1988. As part of that new plan, about 12.000 computers have been installed in 1984 not only in "lycées" (2.500 of these in France) but also in "collèges" (twelve to fifteen years old) of which there are about 5.000 and finally in elementary schools of which there are about 36.000.

The 1985 plan

During the last few years, the program of the French Government may be summarized as follows :

| | 1982 | 1983 | 1984 |
|---|---|---|---|
| Equipment cost (in million $ US)..... | 7,8 | 8,8 | 24,7 |
| Cost of training of teachers (in million $ US)..... | 5,5 | 9,5 | 20 |

| | | | |
|---|---|---|---|
| Number of teachers trained..... | 4200 | 11000 | 20000 |
| Number of microcomputers installed..... (cumulated) | 3000 | 15000 | 40000 |

During a press conference held in Paris on 25 January 1985, the Prime Minister, Laurent Fabius, officially announced a plan aimed at introducing another 120.000 microcomputers in schools and training 100.000 teachers before the end of 1985.

This will bring the total number of computers to about 160.000 for a total school population of about eleven million and the number of trained teachers to about 150.000 (about 25% of the total number of teachers).

The total cost of about 200 million dollars US for the fiscal year 1985 will be split approximately as follows :

Equipment..... 150 million $ US

Teacher training..... 25 million $ US

Courseware..... 25 million $ US

<u>The aims</u>

The scope of the new plan is much wider than just adding another 120.000 computers to those already in use in schools. The plan is called "Informatics for all" and is aimed to familiarize the whole population with the use of computers; for that purpose, it has been decided that the schools will be open after class hours to allow citizens free access to the computers under the supervision of the school teachers who have already been trained.

Teachers training

The training of teachers has been organized during school holidays to avoid perturbating normal schooling and was on a voluntary basis. Three periods were available : the Easter holiday, the summer holiday and a one week holiday in early November.

The training was organized for groups of about twenty to thirty teachers and lasted five full days. During that period, teachers were taught to manipulate the equipment and how to use the different kinds of software which came to schools together with the equipment (details below on this topic under the heading "software").

During the two weeks of the Easter holiday in 1985, it was initially planned to train 500 groups of teachers, but the great number of volunteers led the Ministry of Education to organize about 620 groups all over France which amounts to a total of about 19.000 teachers; about 5.000 sessions in 1.000 centres were planned during the summer holiday (fourteen July to end of August) and the last sessions were to be organized at the beginning of November where there is a one week holiday for schools.

To encourage teachers to come to training sessions during their holidays and to help them to travel (generally short distances because of the decentralized organization of the sessions) and to cover some of the related expenses, each participating teacher received from the Ministry an amount of about 130 $ US.

Software

From the beginning, it was decided that each school receiving equipment would receive at the same time a software box including some fifty software packages. All

French and foreign companies in France were invited to propose their products to the Ministry. A small "Software Committee" of experts, with Prof. J. HEBENSTREIT as Chairman, was set up by the Ministry to make a choice between the proposals received.

This Software Committee set up the following guidelines for its actions :

1) over 60% of the software box should be educational software in the strict sense : math, physics, biology, history, geography, french, foreign languages, arts, etc, excluding games.

2) Between ten and twenty per cent of the software box should be general tools or home application oriented : text-processing, spreadsheets, database applications, computer-aided drawing, etc.

3) Every selected package should be tested technically (bugs, deadlocks, ergonomy, etc) and pedagogically for soundness.

4) Any submitted package using a foreign language selected by the Committee should be translated into French.

5) Only half of the total budget for software should be spent on software boxes. The other half should be used by the schools as an open credit to make their own choice in a coming official software catalogue to be put together by the Software Committee before the end of the year with the same criteria as above.

6) All equipments should run either under CP/M or MS/DOS or, at least, should be compatible with these two; also three languages should be in each box :

BASIC, LSE and LOGO (more languages will be available in the coming software catalogue).

7) One or two author-languages should be available.

8) Only a very few educational games should be in the software box, mainly for the purpose of attracting the visitors coming in during after class hours.

A total of 696 software packages were submitted, including about 200 packages from the Centre National de Documentation Pédagogique, which is an institution of the Ministry itself and whose products are, therefore, free for the Ministry.

The commercial terms for buying software packages may vary from company to company and are under discussion (buying the packages and the documentation directly from the manufacturer at a discount price, including the right to copy the software inside a school, buying a license for the product from the manufacturer with the right to make a certain number of copies, etc).

Hardware

Different types of equipment (about 98% produced by French manufacturers) will be given to schools, the remaining 2% being left open for foreign computers.

33.000 schools having less than 400 pupils will each receive one Thomson T07-70 (64k byte memory, 8-bit microprocessor, standard color TV set, using a magnetic tape cassette recorder for secondary storage and/or ROM cartridge and a printer).

11.770 schools (six to eleven years old) and "collèges" (twelve to fifteen years old) and 500 "lycées" (sixteen to eighteen years old) will receive what is called a "Nano-réseau", which is a local net made of a "professional" (IBM-PC compatible) microcomputer used as a server linked to six microcomputers of the home-computer type (these six can be up-graded up to thirty-one). Moreover, each "lycée" will receive three microcomputers of the "professional" kind.

All together the 120.000 microcomputers will include 14.000 (BULL, GOUPIL, LEANORD, MATRA) of the "professional" kind and 106.000 of the home-computer kind (THOMSON, MATRA, EXCELVISION).

Conclusion

As already noted, "the 100.000 micros at the end of 1985" project has many purposes :

- to increase the pedagogical use of computers,
- to train a significant number of teachers in their pedagogical use,
- to encourage the production of courseware,
- to familiarize the whole population with the use of micros,
- to encourage local authorities to participate in the increase of the number of computers in schools.

1.4.- Conclusions

The way computers have been introduced in schools are very different in the three

"Advanced Countries" because their educational systems are different.

In the USA teacher training has been completely left to local initiatives while in the UK two teachers per school, at least, had to be trained to entitle a school to get a 50% discount on the equipment; in France, training of teachers has been considered very important (some 50% of the money spent for hardware went for teacher training).

In all three countries the policy of using computers is almost the same : to improve education and to familiarize children with the use of computers.

In all three countries also, because there is an increasing awareness of the impact of computers on education among teachers, and because of the increasing number of computers available, there is already research going on on how the widespread use of computers will change the content of the subjects taught and how it may change the very curricula. In all three countries also, the availability of courseware remains a bottleneck in quantity as well as in quality and no short-term solution is in sight.

In all three countries the present ratio of one computer for about 60 children is considered as a first step and some experts are already trying to extrapolate to what education will become when each child will have his own portable computer as he has today his pocket-calculator.

Some of these experts believe that in this case it may well happen that the CAI mode which is presently the dominant use of computers in schools will become marginal as compared to other uses of the computer by pupils : scratch-pad, personal data-base, text processing, automatic spelling-errors correction, assisted text translation, assisted problems solving, various simulations, etc.

2.- The developed countries

In this group of countries, some are rather near to the group of "advanced countries" whereas others are just starting to define a policy for the use of computers in education.

In countries like Australia, New Zealand, Denmark, etc, from 50% to 90% of all secondary schools own at least one microcomputer but they are mainly used to teach informatics as a discipline or for data processing applications in professional training; this is why in these same countries there are very few computers in primary (six to eleven years old) or lower secondary (twelve to fifteen years old) schools.

In all developed countries, governments have plans for the introduction of computers in education and they all have to solve the same problems.

The hardware problems

Despite the low price of microcomputers (as compared to main-frames), their introduction in the educational system rises a financial problem because of their number. In most countries the school population is about 25% of the total population and to have a significant impact on education this implies to install microcomputers by the millions.

Because it is a tremendous potential market for the manufacturers the hardware problem has become in most countries a political problem.

Except the USA (because they manufacture 70% of the world production of computers), in most countries there are policies to encourage buying computers manufactured in the country (UK, France, Japan, Federal Republic of Germany,

etc) mainly when these computers are bought with governmental funding. In some countries which do not have a national computer industry, efforts are made to start such an industry based on the school market (New-Zealand, Australia, etc).

In the USA the existence of this school market has started a competition between companies which either propose heavy discounts if the computers are bought in great number by a school or propose to give computers free to schools provided the government agrees on tax-exemptions for the company.

Official funding policies for buying hardware for schools varies widely from country to country depending partly on the administrative structure of the country and of the structure of the educational system.

Two extreme examples are the UK where the Micros in School project (Ministry of Industry) pays half the price of a microcomputer bought by any school provided the computer is chosen between two british-made models with the aim of having one micro in each of the about 30.000 elementary and secondary schools and France where the computers are completely paid through official funding at the rate of eight micros in each school with the aim of having 160.000 micros in elementary and secondary education in 1985.

In federal countries and in those where private schools are an important part of institutional education, funding is national or regional and/or local depending on circumstances.

The software problems

A few years ago there was no educational software problem because, as already said, most of the uses of computers in education were experimental and in that time researchers were writing their own software for their own use.

As the number of computers in education began to increase it became evident that it did not make sense to ask each teacher using a computer to write his own software (current evaluation is 200 to 300 hours of work to write a one-hour-interaction programme).

However private companies were reluctant to enter the market of educational software for a number of reasons (the small number of computers in schools made the market too small to be able to sell products at a price level compatible with what schools could afford, impossibility to predict or to guess the number of copies sold in a given time, necessity of having as many versions of each programme as there are computer models and/or programming languages, no provision for software in any school budget, etc).

Therefore in many countries the process has started through local initiatives mostly in computer science departments of universities where the manpower was paid through research contracts with more or less official funding (National Science Foundation in the USA, NDPCAL project in the UK, off-duty time given to trained teachers in France, etc).

It is only quite recently that private companies (mainly book-publishers) have started to invest in this area, asking interested teachers to propose detailed pedagogical scripts and hiring computer specialists to write the software and an increasing number of software package is becoming available.

In France there is a competition between private companies and a government-funded institution (Centre National de Documentation Pédagogique) which centralizes all the educational software written by teachers and gives away free a copy of it to any school asking for it.

For the time being most companies believe that the real market for educational software is the home-computer market and try to enter that market by developing "educational games".

For all these reasons the amount of available educational software is very small and will probably remain so at least as long as the production of educational software will remain a "cottage industry".

The teacher-training problems

In some places there is a feeling that there is a teacher training problem only when teachers are asked to teach informatics or computer literacy.

This is true of course but it is not the full picture. Even if there is no teaching of informatics or computer literacy but only the use of educational software there is still a teacher training problem and this is perhaps a more difficult problem than the previous one because it is rather easy, in terms of content of the training, to teach about computer and their use (there are already well-established curricula for that purpose at least for professionals) whereas it is extremely difficult to teach about the proper pedagogical use of computers in the classroom for the very simple reason that there is no previous experience on which to rely.

It has been said that computers can improve education if they are used at the right place, at the right time, with the right amount and in the right way but to meet all these conditions teachers have to be trained to use the computer that way.

The mere presence of computer in schools does not guarantee that education will be improved and the unskilled use of computers in education can even produce worse results than not using them at all.

While heavily emphasized in the Carnegie Report on "The fourth revolution" as early as 1972 the prerequisite of teacher training before starting activities in CAI has only been slowly recognized. The reason of this slow recognition is probably that the idea of teacher training because of technological progress has appeared as something new in institutional education in most countries and also perhaps the scale and the difficulties of the problem. Whatever the reason for that slow recognition of the problem, teacher training is today almost everywhere an important part of any plan to introduce computers in education. In the UK, in the fourteen regions in which England has been divided for the MEP project, there are a variety of courses available in each regional centre : a three days course, a one week course, a three months course and a teacher's teacher course and some of these courses are compulsory, for at least two teachers from each school which buys a computer at half the price with the help of governmental funding.

In France, in each school which receives a package of eight microcomputers paid by the government there is a twelve days course in that same school to which all teachers are invited. Moreover twelve centres have been created in universities where about 600 teachers are trained each year during a full academic year to become either teacher's teachers or authors of educational software. About 20.000 teachers have already been trained through this scheme.

The costs of teacher training are impressive. In France from 1970 to 1978 about two million dollars have been spent for that purpose which have risen to about five million dollars in 1981-1982 and equivalent sums have been spent in the UK. In France in 1983-1985 about twelve million dollars will be spent to train approximately 120.000 teachers.

Evaluation problems

As already said, CAI activities as well as teaching of computer literacy have been

heavily funded through governmental aids in most countries.

These financial efforts have been made by governments with the aim of improving education through the use of computers and as a consequence in most countries, committees were set up to investigate and try to evaluate how the funds were spent and what kind of improvements have resulted.

These "evaluation reports" should normally compare the results of teaching with and without computers and try to draw conclusions on the impact of the use of computers in education.

In fact most of these reports discuss the financial and quantitative results of the experiments (how the money was spent for hardware, software, training, staffing, etc, and how many computers were bought, how many software packages were written, how many teachers and how many students were involved, how many hours students spent weekly on a terminal, etc).

In those parts of the reports dealing with the pedagogical changes induced by the use of computers the emphasis is mainly on what is changing in the classroom (changes in the attitude of the teacher, changes in the behaviour of students, changes in the content of what is taught, etc) much more than on the strict comparison between the same course taught with and without a computer.

This very content of the reports shows convincingly that this kind of comparison which was considered as the justification for CAI in the sixties, is considered today as an exercise of academic interest only and that the problem is elsewhere.

It is considered today that the use of computers in education :

- allows pedagogical strategies which could not be used otherwise,

- allows to teach subjects which could not be taught otherwise,

- allows through proper use of CAI to familiarize students with the mair applications of computers (graphics, simulation, text processing, data banks etc),

- allows students, at a given age, to handle more complex subjects and problems,

- allows improvements in the autonomy and creativity of the students.

All these changes are almost impossible to evaluate because of the absence of a proper term of reference the changes being so drastic in terms of content and methodology of teaching that the state of the art of the present day teaching is not felt to be the right term of reference.

This is probably the reason why in most reports, the use of computers in educatio is much more justified by the necessity to adapt the educational system to th "computerized society" of tomorrow than by evaluating the improvements brough to present day education.

Conclusion

The use of computers in education has been investigated since the early sixties.

Some limited experiences have been made in schools during the seventies but th price even of minicomputers was too high to make a generalized use of compute in education possible.

However the birth of the microcomputer in the late seventies has led a number of governments to set-up ambitious projects for the introduction of computers in education with the double aim of improving education and to use the educational market as a basis, for the development of a national industry in microcomputers and in educational software.

Whereas in the sixties and seventies the main argument for using computers was that CAI was less expensive and/or more efficient than traditional education, the fast invasion of the developed societies by microcomputers is changing the argumentation.

Therefore it is argued today that computers in education are necessary to prepare children to live in the future "computerized society" and the concept of computer literacy is therefore emphasized with a great importance given to teaching informatics and mainly programming to all children.

Finally beause the use of computers is becoming more and more "user oriented" or "friendly" (the communication with computers in natural language is a very active subject in research) there is a strong tendency to use computers in CAI in modes which allow children to become familiar with the use of computers in various applications (graphics, simulation, spread-sheets, data banks, text processing, etc) the teaching of informatics in schools being left as an optional subject.

Moreover it is felt that the use of computers in education is going to give all children more and more powerful tools (in the form of increasingly sophisticated software packages) and the use of these very tools will in turn lead to successive up-gradings of all curricula in schools.

All in all, computers are going to be used increasingly in education. However it should be kept in mind that for the moment being computers are used in education

at a very small scale in any developed country : in terms of total school population the rate varies from one computer for a hundred children to one computer for a few thousand children depending on the country.

3.- The developing countries

The levels of development of the countries from this group vary considerably from country to country and this remains true when it comes to informatics and the use of computers in education.

Some of these countries have well established curricula in Informatics at University level (North-Africa countries, Iraq, Argentina, etc) and some of them are even starting a national computer industry (India, Brazil) whereas others have to send their students to foreign countries for training.

However, when it comes to the use of computers in schools, almost all of these countries have the same problems in a form or another.

3.1.- The use of computers in education in developing countries

Computers have been introduced in education in developed countries :

- to improve education,

- to prepare children to the "computerized society" of tomorrow,

but the perspectives, the techniques, the methods and the objectives of that introduction have implicitely taken into account the general background (educational, social, technological, etc) which exists in developed countries.

There are therefore many implicit factors which have played a basic role in the shaping of the experience accumulated during the introduction of computers in education in developed countries.

This implies that the accumulated experience in developed countries in terms of policies and products cannot be simply transfered is it stands to developing countries with their wide spectrum of different general backgrounds, without serious risks of failure.

There is unfortunately no such thing as a universal method for introducing computers in education and therefore any country wishing to introduce computers in education should start from the general background and the educational problems of the country to thoroughly and carefully analyze the experience accumulated in developed countries to determine how that experience and which parts of it can be used for the definition and development of a national policy.

The environment problem

In developed countries children are brought up in an "industrial environment" where they get familiar with all kinds of more or less complex machines either by seeing them operated by others or by using them : electric can openers, vacuum cleaners, washing machines, vending machines, videogames, electric and electronic toys, lifts, escalators, cars, trains, planes, etc, are parts of their daily life.

That same industrial environment is a constant source of messages (in printed form or picture form) or signals ( flashing lights, traffic lights, etc) which children learn naturally to decode and interpret correctly in terms of their environment.

The whole educational system in terms of curricula content and in terms of pedagogical strategies takes implicitely into account the kind of knowledge or

specific intellectual abilities children have alreay acquired through their experience before they go to school.

These same cultural differences show up when it comes to the use of computers in education :

- the use of a keyboard is easily mastered by most children from developed countries as they have a wide practical experience of pushing all sorts of keys and buttons in their daily life,

- the texts and pictures presented on the screen of a terminal as well as the questions a student is asked during a session on the computer have been designed by the author of the educational software package with the implicit assumption that the student has the kind of "industrialized society background" already mentionned. Under these circumstances it becomes evident that the decoding or interpretation or understanding of the presented texts, pictures and questions will in many cases be different from the authors assumptions when the package is used by a student with a different cultural background and the whole package will therefore appear as inefficient or, in some cases, as a complete failure.

  The implications of these "environment problems" will be discussed later on under the heading "software problems".

The educational problems

The educational system of any developed country, when considered from a global point of view, does approximately respond to the needs of the country. The educational system of any developed country is traditionally criticized in terms of costs, efficiency and adequacy but globaly all these systems turn out each year the

approximate amount of manpower at all levels of competence required to keep the economy of the country going.

Therefore the observed changes in the educational system in a developed country are much more a problem of evolution or partial adjustments to meet the changes observed or predicted in the country or in society at large than a problem of major efforts to overcome the kind of difficult and massive problems which exists in developing countries.

This remains true for the introduction of computers in education which, in developed countries, aims mainly, as already stated, to improve education and to adapt it to the "computerized society" of tomorrow whereas the right question to ask in developing countries is how can the use of computers in education help to improve and adapt their educational systems which may appear to be the same problem but which are in fact different problems because they are formulated in different contexts (to improve education is a different problem in a country where there are enough teachers at all levels in all schools and in a country where there is a lack of teachers or where adult alphabetizattion is a major concern).

That is why what has been said in the first part of the report about the different modes of use of computers in education should not simply be transfered to developing countries but should be analyzed and reappraised in the light of the context of each country.

It has been said, for instance that the tutorial mode is not very popular with teachers in developed countries except as a remedial help for low-achieving children but the reason of that appraisal is that there are enough teachers. In a country where there is a lack of teachers what kind of help can be expected from the use of the tutorial mode to replace the missing teachers ? is it worse or better than no teacher at all ? and even more, can the tutorial mode be used for

autonomous teacher training if there is no other possibility ? This kind of question has never been investigated in developed countries for the very simple reason that these problems do not exist in developed countries.

Therefore, if the answer to the preceding questions is yes, who is going to define the content of the necessary educational software packages to make sure that they do fit the cultural background of the users of the packages ?

Specialists from developed countries have little competence in that last area but their general experience can be used through cooperation with national educational authorities from developing countries which have the competence to decide what is and what is not adapted to their national cultural background in terms of pedagogical strategy.

The software problem

As already mentionned, educational software packages designed in developed countries carry with them, implicitely, the general background of these countries and should not be used without caution in developing countries for a number of reasons :

- the packages are written in a specific programming language and impose very frequently the use of a specific type of computer which may be more or less well adapted to local needs,

- if they are used in a country with a very different general background there are two difficulties :

  The first difficulty is a possible lack of efficiency of the packages due to the misadaptation between the content of the packages and the general

background of the user.

The other difficulty is a more subtle one and perhaps a less visible one. The educational system of a country is the place where national culture and traditions are transmitted to the young generation. Willingly or not, the educational software designed in a country carries with it, in many subtle ways, the social and moral values of the culture of that country and therefore the massive use of educational software designed in a foreign coutry will slowly but inevitably lead to a transformation and eventually to a decline of the originality and specificity of the national culture and traditions. This kind of difficulty is already well known regarding school books or books in general but it is much more difficult ot analyze in the case of interactive educational software packages.

The ideal solution of these problems is of course to design locally the educational software packages to be used in a country or to use packages from countries with more or less analog general backgrounds. This is not possible for the moment because of the lack of specialists in most developing countries but a cooperation with specialists from developed countries can help tremendously to overcome the mentionned difficulties and to start local production of educational software. More will be said on that subject under the heading "teacher training". There is at least one more software problem which is at the same time a financial and a technical one. All software packages are covered by some form of copyright which makes it illegal to make a copy. This implies that it is necessary to buy as many copies as there are computers. It is however possible in some cases to make a licensing agreement through which copying becomes a legal activity and this would probably be a good solution for developing countries because it would allow to create national centres in charge of the copying activity thereby initiating a technical activity related to the educational use of computers, including a group in charge of rewriting the accompanying technical and pedagogical documentation to

adapt it to the national background and environment.

The teacher training problem

As already stated in the first part of the report, teacher training is considered in developed countries as a prerequisite to any introduction of computers in education. More and more warnings are given to schools not to buy computers or even not to accept computers as gifts unless they know exactly what they are going to do with them. It has also been said that teacher training is a necessity whether these teachers are intended to teach a new subject as computer literacy or whether they are intended to use the computer as a pedagogical tool in their normal teaching activity.

The training of teachers is as important in developing countries as it is in developed countries (there are examples of computers bought by schools in developed countries and which have never been used for the simple reason that the teachers don't know how to use them or don't see any reason to use them) however the problem of training teachers in developing countries is different from that same problem in developed countries because the contexts are different.

First of all in developed countries there are specialists in computer science available, even in those countries which do not manufacture computers, because curricula in informatics do exist in universities for a number of years and it should be kept in mind that the initial work on CAI has started in the informatics departments of universities.

In most countries some of these specialists have been used as staff for teacher training at least at the beginning. This had some drawbacks because these specialists had a natural tendency to teach their own discipline (i.e. informatics) without paying sufficient attention to the training in the pedagogical use of

computers but it helped to start the process.

It is true that in developed countries there is a relative lack of specialists in informatics, but the situation is considerably worse in developing countries and therefore the problem of finding the staff for teacher-training is much more critical.

It is not only critical because teacher training is a prerequisite for the effective use of educational software, it is also critical because teacher training is also a prerequisite for starting a national production of educational software (the cultural importance of that activity has already been stressed in the paragraph on the software problems).

More will be said on teacher training in the paragraph "Policy problems".

The hardware problems

Some of the hardware problems are common to developed and developing countries because they are purely technical problems :

- there is a great variety of models of microcomputers and they are incompatible between themselves : they don't have exactly the same programming languages nor the same operating systems (a software package which runs on one model does not run on another one), or the same standards even inside the same company depending on the model,

- each year some companies disapear while others are created so that after some time there are no maintenance nor spare parts,

- every year more sophisticated models are available (high resolution graphics, color screens, touch-sensitive screens, flat screens, sound, network connexion possibilities, "mouse", joysticks, connexion to video cassette recorders and

video disks, etc),

- there is now a wide spectrum of models available from 60$ (using a television set as a screen) to over 6000$ (including printer and hard-disks) and rises the question of which model to buy for education.

However there are other problems for developing countries :

- how does a given model resist to certain local environments (heat, humidity, insects, etc),

- how does a given model behave in presence of variations in voltage and frequency of the electrical network,

- no microcomputer with a floppy disk, a cathode ray tube and a printer can run very long on batteries and moreover batteries are very expensive and not always readily available,

- maintenance can be a very critical problem outside of big cities and even in big cities when the manufacturer does not have a permanent local representative.

All these problems make the choice of a microcomputer for education something very difficult and all the mentionned aspects should be carefully investigated before making a decision.

2.2.- Policies and strategies

The introduction of computers in education at any level (schools, technical training institutes and universities) and whate ver the purpose (general computer literacy,

improvement of education or training of specialists in informatics) requires a long term policy because any educational system reacts rather slowly to policy changes (a reaction-time of a few years is typical).

The increasingly massive use of computer in developed countries has been possible because of the existence of professional levels of training in informatics and is in turn pushing the developed countries to increase their effort to introduce computers in general education.

The main axis of the applications of informatics in education

As already said, the policy of introducing computer in education in developed countries has been a kind of three-step policy :

1) training specialists in informatics at the level of a Master degree or Engineering degree and simultaneously at the vocational level (analysts, programmers, maintenance).

2) based on the existence of these specialists, the use of computers has spread to other departments and laboratories of universities (Electrical engineering, Physics, Chemistry, Biology, Management, Economics, etc).

3) the massive use of microcomputers in industry, commerce and administration which are increasing the productivity of manpower and will allow to produce cheaper, more sophisticated and more reliable products has lead to the decision to introduce computers at all levels of education starting with primary schools. But this last step is considerably facilitated by the existence of the two previous one.

It seems difficult to define a policy which does not include these three steps in the

defined order because the implementation of each step is a kind of prerequisite to create the teaching staff for the next step.

In any country, therefore, the definition of a global policy depends strongly on the level of implementation of each step in the educational system of the country. However it should be possible to accelerate the process of introduction of computers in education in developing countries either through regional cooperation or through cooperation with developed countries.

Finally there are problems which are specific to developing countries like alphabetization, adult education or scarcity of teachers in various disciplines. These problems would probably be easier to solve through the use of computers but little has been done for the moment in this respect and more research is necessary to develop the right methods adapted to the different levels of development and to the different cultural background.

The professional training policy

The training of professionals in informatics at university level and at the vocational level has already started in many developing countries in parallel with the use of computers in these countries.

To define a policy in this area has become easier over the years because :

- the problem has been well investigated,
- there is an impressive number of existing curricula (including a UNESCO-IFIP curriculum),
- the content is a scientific and technical one and does not imply any reference

to a cultural background.

Therefore the definition of a policy is a problem of resources in manpower, installation of the right equipment and evaluation of national needs of specialists over the next years. It does not mean that it is easy but the number of people involved as well as the cost of equipment is very low when compared to the problem of the general introduction of computers in education.

The use of computers in school education policy

In most developed countries (including the USA) there is not always a national policy for the introduction of computers in education at school level and it is happening most of the time because of local or regional initiatives.

However with or without a national policy the number of computer in schools has increased slowly over the last few years and is increasing more and more rapidly, the objective being to have enough computers in the educational system to allow each student to use a computer for about one half hour a day. For the moment being there is statistically about one computer for every few hundred students or few thousand students depending on the country and the objective mentionned of one half hour/day use per students implies that the present number of computers has to be increased by a factor between ten and fifty.

Moreover depending on the country about 20% of all installed computer will have to be replaced each year because a computer does not last more than five to seven years. The costs involved may seem very important but they are meaningful only if they are compared to the total budget of education.

Such a study has been made in the USA for the current costs based on the assumption of 2,5 million computers in primary and secondary education (about

one computer for twenty children). The result of the study (including the replacement of 0.5 million computers each year and the cost of the software to be changed every three years) is that the cost does not exceed per year about 1% of the total budget for primary and secondary education. This study has been criticized because it does not include the cost of maintenance and the cost of teacher training but it is interesting because it gives an order of magnitude of the impact of the use of computers on the total budget (the cost of education being a more or less constant part of the National Gross Product of any country - 4% to 6% as shown by UNESCO statistics).

For developing countries however these statistical results have to be taken with great care and reanalyzed in the light of their national economic conditions.

One important issue in deciding about a policy is to whether children should be taught technical computer literacy (structure of computers, programming, etc) or if the computers are going to be used as pedagogical tools including familiarization with the use of computers. Teacher training problems are not the same in both cases and more will be said about this issue under the heading "Teacher training policy".

Another important issue is where to start the use of computers in education (primary or secondary education). In most developed countries it has started with children at the age of fifteen-sixteen, the rationale behind that policy being two fold : first, it was widely believed that at the age of fifteen-sixteen, children were more able to cope with computer than at a lower age and second, only the most gifted or most able children continue to go to school at that age. One more reason (never officially stated) was that teachers in upper-secondary education have, in general, a higher academic degree and should therefore be easier to re-train.

There is no evidence that this kind of policy does systematically fit the needs of

developing countries and the definition of where to start in the age-scale is an open issue.

Moreover, as already mentionned, there are problems which are specific to developing countries as alphabetization, adult education and a general lack of teachers.

The kind of priority to be given to the use of computers to solve these specific problems is also an open issue. Finally, even when priorities have been defined there remains the general problem of deciding the speed of development in each chosen direction which in turn depends heavily on the possibility of funding and the intrinsic slowness of reaction of the educational system.

The hardware policy

The main hardware problems have already been mentionned (physical environment, maintenance, non-portability of software between different types of computers, etc).

Some more problems should be investigated before defining a hardware policy like, for instance, the availability in a near future of "multimedia computer-based devices" like the computer controled video disk including sound and speech at prices which are competitive with the stand-alone microcomputer.

Another aspect which could influence the definition of a policy is the existence of a national telecommunication network which could be used for down-loading educational software directly from central or regional computer to the local microcomputers through telephone lines or give access to regional or national educational data banks, etc.

Finally in some countries, the introduction of computers in education could offer a possibility of starting a national activity in microcomputers manufacturing through licensing or arrangements with the equipment manufacturer as it is already the case in other industries like automobile or avionics. Much depends of course of the availability of qualified manpower or the possibility of training existing manpower for that purpose.

The software policy

Professional softwares (for data processing or scientific calculations) are more or lessuniversal in the sense that their use in any country requires only small local adaptations and this is even true for softwares which are more sensitive to local differences like text-processing (there are differences in the required keyboards for English, French, Swedish, or Russian but this has been taken into account during the design process and necessitates only small changes in the equipment or the software).

Educational software on the contrary is mainly composed of texts to be presented to the student and of questions the student has to answer. There is therefore a language barrier as soon as the software is used in a country speaking a different language.

However the importance of the market and the demand for educational software is such that in many countries, educational software is imported and translated in the national language.

It has already been emphasized in the paragraph on "Software problems" that there are two important issues regarding imported software :

- any educational software, even translated, is an implicit vehicle of the cultural

values and traditions of the country where it comes from. Therefore the massive use of imported educational software can become, if it is not carefully controlled, a certain form of "cultural colonization".

- any educational software has been designed by its author with a number of implicit assumptions of the cultural background of the future user. If the user has a different cultural background from the assumptions made by the author the software will prove inefficient or can even be a complete failure.

Therefore educational software should be designed in the country where it is going to be used or at least in a country with about the same general background and with more or less analog cultural values and traditions.

The decision to start a national production of educational software is an important part of any software policy even if it has to start at a very small scale (pilot projects, national or regional centres, cooperation with specialists from developed countries are possible strategies to start such an activity).

Because few specialists are available in developing countries, a national activity in educational software production is tightly linked to the teacher training problem.

The teacher training policy

We shall consider separately two aspects of teacher training :

- Training teachers to use computers in schools

If the policy is to teach informatics in schools the training requires a rather long time (one month full-time seems to be a minimum) because the subject is a completely new and difficult one.

If the policy is to use computers as educational tools, the training can be much shorter (one or two weeks to learn how to connect and start a computer and how to execute an educational software package) provided each package includes a documentation giving a full description of how to use that package in pedagogical terms. The training can be largely a self training if specific software packages for teacher training are available or are developed for that purpose.

If computers can be used to teach children, they can also be used to train teachers. This aspect of the use of computers (using computers to teach teachers how to use computers in education) has been little investigated in developed countries and could be an important subject of research in developing countries.

- Training teachers in any discipline

Because there is a scarcity of teachers and even a greater scarcity of staff for teaching teachers in developing countries, the possibility to use computers for teaching teachers can be of great help in these countries.

This problem has been very little investigated in developed countries because the mentionned problem does not exist but it may help to solve the problem which exists in developing countries.

The best place to work on that problem are probably the institutions where teachers are normally trained.

Finally teacher training in the educational use of computers is a prerequisite of starting a national production of educational software. This however implies an

in-depth training of a small group of teachers which could be the starting point of a group including these teachers, specialists in psychology and pedagogy and informaticians with the aim of starting the production of education software.

Any teacher training policy should include the aims and scope of the policy, the number of teachers to be trained each year, the different levels of training with their objectives and an evaluation of the costs including the necessary equipment for the training.

Research policy

The use of computers in education will increase over the years and many problems related to their use are still open even in developed countries :

- cognitive problems to be solved to improve the efficiency of the use of computers (modelling and structuring of knowledge, better understanding of learning activities, etc),

- the influence of technology on the curricula at all levels of education,

- ergonomic aspects of the use of computers,

- etc.

It has been emphasized many times that the use of computers in education in developing countries raise new and different problems and this implies the necessary definition of a research policy to investigate these specific problems.

## 2.3.- Conclusion

The introduction of the use of computers in education has started in developed countries a few years ago for a number of different reasons (pedagogical, social, economical, industrial, etc).

Progressively, often through trial and error, a methodology of use is emerging and the educational authorities are becoming aware of all the different implications (hardware, software, teacher training, research, curricula content changes, costs, etc).

For the first time in history technology is invading education and is going to change its methods and contents.

There is, without any doubt, a definite danger of an increasing gap in level and quality of education between those countries using massively computers in education and those which do not.

The use of computers in education in developing countries can however be a way of decreasing the gap, provided it is done through the careful definition of a policy taking into account the cultural and general background of each country and incooperation with developed countries for the transfer of the already accumulated knowledge and know-how.

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